UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

LEVEL II

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER II Technology Exchange Week Panama, RP	2. GOVT ACCESSION NO. AD-A108784	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) REMOTE SENSING IN LATIN AMERICA: TECHNOLOGY AND MARKETS FOR THE 1980s		5. TYPE OF REPORT & PERIOD COVERED N/A 6. PERFORMING ORG. REPORT NUMBER N/A
7. AUTHOR(s) Lawrence J. Jungman		8. CONTRACT OR GRANT NUMBER(s) N/A
9. PERFORMING ORGANIZATION NAME AND ADDRESS Defense Mapping Agency Inter American Geodetic Survey, Building 605, Ft Sam Houston, TX 78234		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS N/A
11. CONTROLLING OFFICE NAME AND ADDRESS DMA IAGS PAO Ft Sam Houston, TX 78234		12. REPORT DATE August 1981 13. NUMBER OF PAGES 14
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

N/A

18. SUPPLEMENTARY NOTES

N/A

DTIC ELECTE DEC 22 1981 S D B

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Remote Sensing
Latin America
Digital Image Processing
International Markets

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A review is made on the impact of satellite derived remote sensing data in Latin America. Data availability has generated a phenomenal growth in the user community in Latin America, and new sensor systems planned and proposed are viewed as a further impetus to an increased market in the Americas. The international institutionalization of remote sensing interests in the area is an indicator submitted as a viable force in the continued, future market and transfer of technology. The availability of required training and funding

(Continued on reverse side)

for special projects by these institutions is reviewed. Proposals are made for special training to prepare for increased digital and cartographic applications that will be required in the expanded users market of the 1980s.

Accession For	
NTIS GRA&I	✓
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	

REMOTE SENSING IN LATIN AMERICA:
TECHNOLOGY AND MARKETS FOR THE 1980S

LAWRENCE J. JUNGMAN
Defense Mapping Agency - Inter-American Geodetic Survey
Building 605, Fort Sam Houston, Texas 78234

BIOGRAPHICAL SKETCH

Lawrence Jungman is the EROS Coordinator of the Defense Mapping Agency - Inter American Geodetic Survey (DMA IAGS), where he is a Program Manager on the Plans and Programs staff. His responsibilities include the coordination of the IAGS EROS Program and the Aeronautical Charting Program with the associate Latin American mapping institutes. He received his B.S. from St. Louis University and has done graduate work in several universities in computer science, cartography and remote sensing. Most of his graduate studies were undertaken at the Ohio State University in 1979-1980. Mr. Jungman has served on active Working Groups on Aeronautical Charting Standards for the Pan American Institute of Geography and History (PAIGH) and is a member of the ASP and past officer of the Panama and Central American Region of the Society.

ABSTRACT

A review is made on the impact of satellite-derived remote sensing data in Latin America. Data availability has generated a phenomenal growth in the user community in Latin America, and new sensor systems planned and proposed are viewed as a further impetus to an increased market in the Americas. The international institutionalization of remote sensing interests in the area is an indicator submitted as a viable force in the continued, future market and transfer of technology. The availability of required training and funding for special projects by these institutions is reviewed. Proposals are made for special training to prepare for increased digital and cartographic applications that will be required in the expanded users' market of the 1980s.

INTRODUCTION

- 3540

Satellite remote sensing in Latin America is perceived as a highly promising technology for hemispheric mapping, charting and natural resource development programs. The objectives of this paper are to review the Latin American market for satellite systems that has evolved over the past decade and postulate a future scenario for the technology and application areas of the science. These objectives are motivated by a conspicuous observation that Landsat has been somewhat oversold to the mapping community in the Americas. There has been a resulting tendency for many of us to underestimate the growing cartographic potential in digital applications and especially that of the future sensor systems.

THE EVOLUTION OF SENSOR SYSTEMS

Apart from conventional aerial photography and photographic interpretation, remote sensing is a relatively new field of study that has emerged over the past 20 years. It has just been the last 10 years or so that articles and textbooks on remote sensing have proliferated to comprehensively cover most of the physical principles and scientific and resources disciplines, their applications and instrumentation on which the science is based.

The launch of LANDSAT 1 in July 1972 ushered in the onslaught of satellite earth resources data availability. The LANDSAT program has since grown in a successful market of international acceptance concurrent with its evolution in technological improvements for both existing and future operational data acquisition systems. Doyle (1978) has documented the essentials and capabilities of most of these systems, with brief descriptions of the proposed French (SPOT), German (ARGUS) and Japanese (JEOS/MOS) earth observation satellites that would complement future US efforts.

The new US systems projected for launch throughout the 1980s are subject to considerable political constraints. As illustrated in Figure 1, the Reagan budget does not include any system beyond LANDSAT D′, the Thematic Mapper. But the whole future of civil remote sensing systems, including the transition of LANDSAT from government to commercial hands, is so wrought with complexities and unknown factors that it is difficult to accurately predict what operational framework will exist. What is all but certain is that there will be a dramatic growth in the amount of digital and analog imagery available for processing and evaluation of earth resources. Extensive research is currently progressing throughout all phases of evaluation and testing of the latest state-of-the-art sensor technology. Much of this research and development is based on multiple linear array (MLA) technology as described by Wharton et al (1981), Welch (1980) and Thompson (1979), among others. These linear array sensor systems are contemplated for use in planned or proposed satellite systems such as the SPOT, STEREOSAT and MAPSAT. The MLA technology will employ a "pushbroom" scanning technique whereby the satellite platform containing the linear array of detectors will sweep across an image scene by the forward motion of the platform rather than relying on an electro-mechanical technique of scanning such as employed on the LANDSATs 1-3 (and planned for the D series). The advantages of this scanning mode and sensor configuration are described by Thompson (1979) and are two-fold: (1) complex mechanical scan mechanisms are eliminated and precise geometric positioning of detectors is allowed; and (2) the dwell time per resolution element is increased, yielding increased signal sensitivity and an improved signal-to-noise ratio. These advantages translate to greatly improved imagery resolutions, which are no less than exciting to the potential user community of earth scientists. Table 1 shows the sensor parameters of the more prominent of the proposed and planned systems.

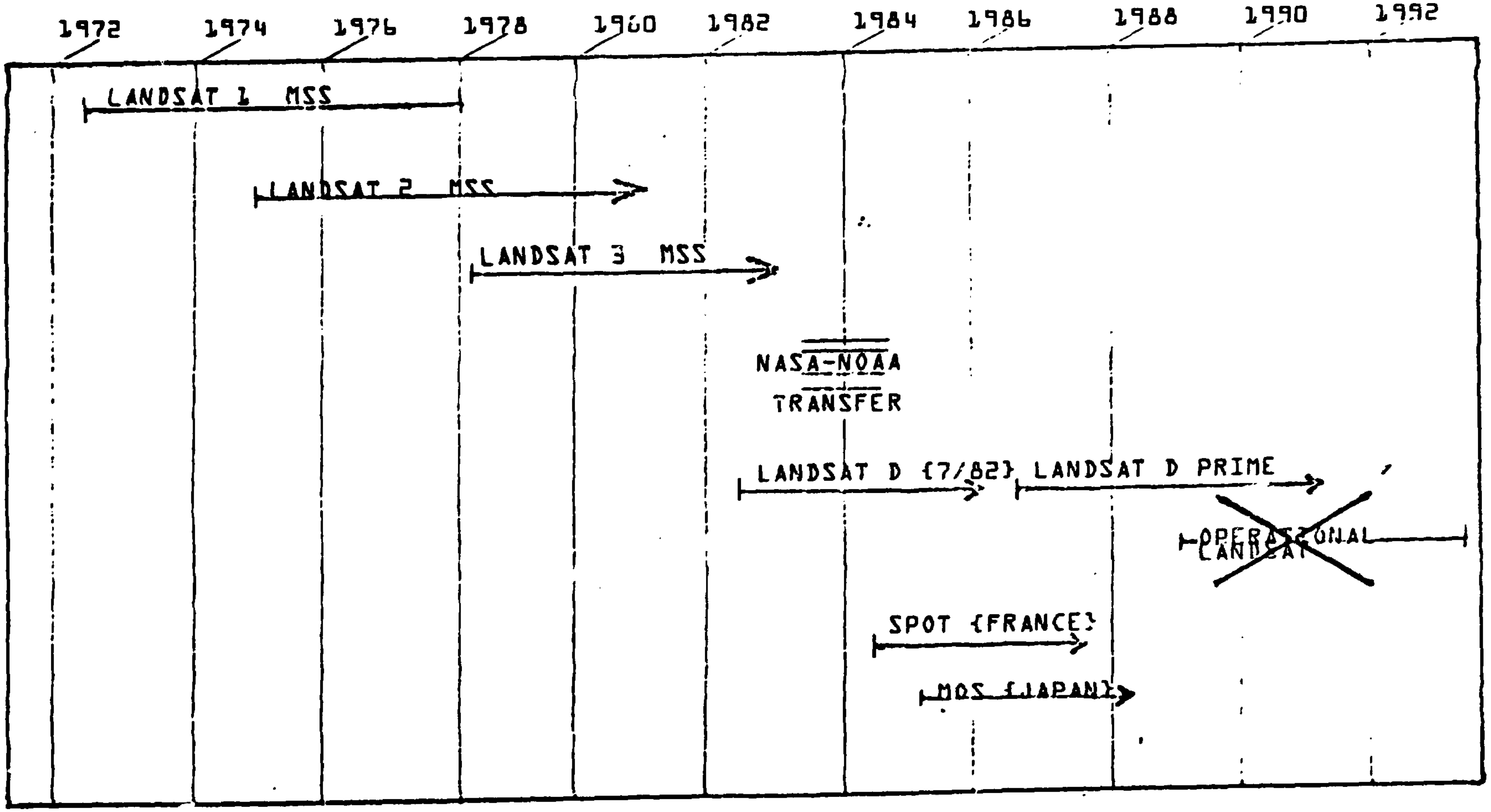

FIGURE 1. LANDSAT PROGRAM 1972-1992

SENSOR PARAMETERS OF PROPOSED
SATELLITE SYSTEMS

SYSTEM	PROPOSED LAUNCH	SENSOR TYPE	RESOLUTION {IFOV}	BANDS	SWATH	CYCLE
LANDSAT D	1982	TM/MSS	30M/76M	7/4	185KM	16-20 DYS
SPOT	1984	HRV{2}	20M/10M	1 PAN 3 MSS	60KM	26 DYS
STEREOSAT	{1985}	3 CAMERA	15M	1	61KM	48 DYS
MAPSAT	{MID-1980 }	3 CAMERA	10-30M	3-4	185KM	18 DYS

TABLE 1.

MARKET EXPANSION

Most significantly, the new systems will contribute to the expansion and evolution of the user community to include more operational uses of the data in all areas of current natural resources applications, and much more in cartography and photogrammetry. The impetus for most of the new systems came from various sectors such as the geologic, hydrologic and cartographic communities, with special demands from the latter, for greater improvement in resolution. Welch and Marko (1981) and Chevrel et al (1981), among others, have pointed out this cartographic potential of the STEREOSAT and SPOT systems respectively. The image quality that can be associated with 10, 15 or 20 meters IFOV promises adequate planimetric detail for maps in the scale range of 1:50,000 to 1:250,000. The added stereoscopic capabilities of these systems hold further possibilities to obtain the so elusive Z data within sufficient accuracies to meet the formal mapping requirements for topographic maps at 1:250,000 scale or smaller (100 meter contour intervals) (Welch 1981). Even more significant is the cartographic potential of the MAPSAT (Automated Mapping Satellite) system as proposed by Colvocorresses (1979). MAPSAT has been defined as a candidate for an operational land remote sensing system to follow the experimental LANDSAT era. From a feasibility study made for them by the Itek Corporation, NASA (1981) reports that MAPSAT conceptually includes the capability for 1:50,000 scale mapping with a 20 m contour interval.

All of these data acquisition systems are proposed and designed with the increased user community in mind. They will all produce data in digital as well as analog form, gathered at rates varying from 30-100 Mb/s and collected at ground stations all around the world. All would produce CCTs for digital processing, and those with stereo capability could be exploited to generate digital terrain models (DTMs) and other digital X, Y, Z data products on a world scale. An optimistic scenario would envision a world or regional community of data users procuring near real-time data from all the systems to provide a combined wealth of improved resolution with improved spectral range imagery of our environment. The availability and simultaneous use of such data would assist the world in general, and specifically the developing countries in Latin America and elsewhere to obtain an otherwise unavailable magnitude of relatively inexpensive resource and mapping quality data.

Market Institutionalization in Latin America.

Shortly before the launch of the first LANDSAT, the Defense Mapping Agency Inter American Geodetic Survey (DMA IAGS) established a joint EROS program with the US Geological Survey (USGS). Under this program the IAGS commenced to assist its associate agencies throughout Latin America in establishing their national EROS data centers within the structure of their mapping institutes. The subsequent flow of LANDSAT imagery from the EROS Data Center (EDC) through

IAGS to the Latin American national centers served to foster considerable interest in this new technology among our Latin colleagues. Workshops, seminars and formal training in remote sensing were incorporated in the IAGS EROS Program and presented at the IAGS Cartographic School in Panama and within many of the associate agency countries.

In a rather simplistic analysis of this program, it can be stated that it has been fairly successful in the area of technology exchange. Hundreds of Latin technicians, cartographers, photogrammetrists and other earth scientists have directly or indirectly benefited from the training and special workshops. Small scale LANDSAT composited mosaics were produced in areas of Central America, Colombia, Ecuador and Chile. Visual analysis and interpretation techniques for multispectral data were taught in conjunction with conventional photo interpretation (PI) expertise employed with panchromatic and color aerial photography. Working closely with IAGS in the transfer of this technology were the USGS, NASA/NASA EROS Data Center, the Pan American Institute of Geography and History (PAIGH) and a number of remote sensing scientists from other US Government agencies, educational institutions and the private sector. Multispectral viewers, cameras and film were purchased by the IAGS and routinely loaned to the Latin American associate agencies for special projects and studies. Digital remote sensing received little emphasis by IAGS in the 1970s.

Despite the overall success of the program, a general waning of interest occurred within the IAGS community during the latter part of the decade. In our enthusiasm to fill those vast Latin American areas devoid of cartographic products, we perhaps oversold the LANDSAT system. We began to realize that those pretty pictures were quite revealing of some little-surveyed territories, but were not of much cartographic value beyond limited planimetric and cultural update of smaller scale maps (such as aeronautical and nautical charts). It was not question of LANDSAT not living up to its expectations but rather the concentrated interests of the mapping institutes in large scale topographic and cadastral mapping. They were and are not seriously engaged in thematic or natural resource type mapping programs and they were, for the most part, not strongly active in map and chart maintenance. The bulk of the market consequently evolved within those agencies and organizations concerned with the investigation of natural resources.

In a 1978 IAGS survey of remote sensing data users in Latin America (which was of limited scope and accuracy) (IAGS, 1978), no fewer than 520 organizations and agencies in government, academia and the private sector were counted. According to Adrien and Bartolucci (1978), the list includes over 300 in Brazil alone. Concurrent with an enlargement of the national user community was an increased international institutional participation in remote sensing activities in Latin America. The Inter-American Development Bank (IDB), the US Agency for International Development (USAID), the Canadian International Development Agency, the International Development Research Center of Canada (IRDC) and the Canada

Center for Remote Sensing were the more active of these participants. Adrien and Bartolucci (1978) present a good synopsis of these international activities through 1978, which represent a major investment in dollars and pesos towards special projects, programs and studies of natural resources and the environment. Large scale projects and studies were undertaken, for example, in Peru, Bolivia, El Salvador, Costa Rica and Chile, with some degree of international institutional support. Some of these studies even included digital analysis techniques.

Other Contributions to the Market.

The technology further spread through greater national agency participation in sponsoring international symposia, special workshops and training programs. For the past several years there have been at least one international symposium per year on remote sensing sponsored somewhere in Latin America. In 1981 at least three have been held in Brazil, Colombia and Chile. Remote sensing continues to receive additional emphasis at other international conferences such as the Technology Exchange Week hosted by IAGS in Panama in 1979 and the planned II Technology Exchange Week to be held again in Panama in early 1982.

Another indication of the growing market in Latin America is the advent of LANDSAT ground receiving stations in Brazil and Argentina, with interests expressed off and on in Mexico, Chile, and most recently in Venezuela. These are also signs of good governmental support for remote sensing in those countries which confirm a certain commitment to future activities in the use and application of remote sensing data from satellite systems.

A final indicator of the market in Latin America is the emergence of technical journals in Brazil, Mexico and Chile during the last decade and a marked increase in related literature. As pointed out by Robinson et al (1977) regarding the growth of cartography, and as recognized by Crane (1972) regarding the growth stages of a scientific field in general, the proliferation of the literature is a good measure of the overall development of the science through some four stages: Stage 1 - preliminary growth period with small increments of literature; Stage 2 - a period of exponential doubling of literature at regular intervals; Stage 3 - a period when the rate of growth begins to decline: and Stage 4 - a final period where the rate of growth approaches zero. Without the substance of extensive research this author suggests remote sensing in Latin America is in Stage 1, but quite close to Stage 2 period of exponential growth. This assessment considers the science as developing in a regional context and is a valid contention since the Latin American area is dominated by the Hispano-Portuguese language reflected in the literature of the region.

THE FUTURE: TRAINING FOR DIGITAL APPLICATIONS

This paper was partially inspired by Spann (1980) who, in writing of the satellite remote sensing market in general, contends that it is on the verge of a dramatic growth and believes the rapid acceleration should occur within the next two to four years. His rationale for the market expansion runs parallel with what this paper advances for the Latin American Market; the advent of improved data quality and increased and timely availability of data plus their economic utility (especially to the less developed countries of the world). Of unique and added significance to the Latin American market in the future is the commitment to that market by the international institutions previously mentioned. These institutions, such as IAGS, USAID and PAICH, have a vested interest in aiding the American nations in mapping, natural resources and economic development in general.

Despite the diverse nature of their distinct missions in the Americas, they are eager to promulgate a variety of programs oriented towards the transfer of technology to accomplish those goals. Of all these agencies and institutions, AID is probably the most visible and active in remote sensing. It is developing plans for as yet undefined programs in Latin America that are beyond its past sponsorship of special workshops, projects and symposia. Until recently, AID was studying the feasibility of funding and establishing regional remote sensing centers in Latin America to assist in development problems, provide training, technical assistance and grants to support local (national) initiatives and institutions and so on (Conitz, 1978). Paul (1981) reports that the regional center concept was deemed not feasible, and other options such as continued sponsorship of national and regional projects are being advocated. Paul (1981) has further stated the desires of AID to work jointly with the IAGS and others to foster technology and programs in remote sensing in areas of mission overlap between agencies. The presumed recipients of such programs would be the national mapping agencies, the agricultural ministries, national universities, and other national commissions and institutes engaged in environmental programs for economic and social development.

The Training Requirement.

To prepare for and fuel the predicted growth of remote sensing in Latin America in the 1980s, the fundamental need for additional and enhanced training of Latin American technicians and earth scientists is recognized. It will furthermore have to progress at a more accelerated rate than that which occurred in the past decade, and will include preparation in the growing field of digital applications. This is not to de-emphasize the visual skills in human image interpretation. Mead (1979), in fact, has reported that five prominent scientists participating in a 1978 ASP sponsored panel titled "Occupational Preparation in Remote Sensing," generally concluded that proficiency in basic image interpretation was the most important remote sensing skill desired. Even those panelists with concentrated expertise in digital image processing agreed that there is no substitute for the eye of a knowledgeable photo interpreter.

As Spann (1980) has stated, the real future of remote sensing goes hand in hand with the computer revolution and the best forecast is for an increase of computer image analysis systems in most application areas. The most recent advances in computer hardware have produced new generations of image processing systems with extensive capabilities beyond the limitations of early systems. Real-time and near-real-time processing and handling of large data bases of remotely sensed imagery is now routinely being done with state-of-the-art friendly, interactive, stand-alone and loosely-coupled systems. Specialized software is available for unique applications using sophisticated statistico-mathematical routines to process, classify and display pixel scenes of LANDSAT and other remotely sensed imagery on color or grey level output devices. Just a few years ago, mainframe or minicomputer based image processing required an investment on the order of several hundred thousand dollars or more. Micro-processor based systems can now accomplish the same results and more (but at somewhat slower speeds) and can be obtained from a host of manufacturers for relatively modest investments of 30-50 thousand dollars.

The advent of 16 bit microprocessors and a possible next generation of 32 bit hardware can be expected to be employed in relatively inexpensive graphics and image processing systems. These systems will permit rather large scale production programs using remotely sensed imagery and other geographic data bases. The ultra high speed processing will lend itself to the handling of huge data bases (up to 300 M bytes) and the possible link up or networking of image processing systems, thousands of kilometers apart, to share or even merge data bases will be a routine operation. Digital processing will permit many new products and rapid service for the enlarged data user community. The new sensor systems will generate the computer compatible tapes (CCTs) of multispectral, multispatial and other types of digital imagery for convenient, computer processing operations around the world.

The training preparation for the growth areas in EDP applications were further discussed in the ASP panel reported by Mead (1979), and the skills identified as of great value in addition to PI were: statistics, computer sciences and math through at least calculus. Our Latin American colleagues must be prepared to acquire these additional skills, together with remote sensing, from the many training avenues offered them through the IAGS, EDC, the Remote Sensing Institute, at universities in the US, and at their national universities where curricula in the science are offered.

The IAGS Cartographic School.

It has been well publicized that the IAGS Cartographic School has in the last few years come under a DMA Headquarters mandate to update its curricula to offer the latest MC&G technologies to its Latin MC&G associates and others in the hemisphere. Revised and newly offered courses in remote sensing are currently listed in the school's 1982 catalog (IAGS, 1982), and are as shown in Table 2. These courses are subject to some change in basic content as described in the catalog. They are currently being reviewed to determine how they can best be presented to interface with new cartographic technologies as well as with a newly purchased Image Analysis System. The latter is expected to be available for operational use at the school in early 1982. It will be a stand-alone micro-processor based system with color video display and some form of hard copy output. It will be an interactive, friendly system, capable of a variety of processing functions to make statistical, supervised and unsupervised analyses of digital MSS data. To further supplement the revised remote sensing courses at the school, a series of short seminars are being tentatively proposed by IAGS Headquarters to be conducted on a periodic basis for selected managers of the associate agencies in Latin America. The idea behind these seminars is to demonstrate digital image processing with the newly procured hardware/software system, and also to promote new cartographic applications in both general and thematic mapping.

The long range direction the IAGS follows in the transfer of digital remote sensing technology in the Americas will invariably be in the MC&G applications areas. In addition to the generation of mapping and charting products, the satellite imagery will be exploited for the merging with and analysis of cartographic digital data bases. Programs of this nature are already in the making at the DMA production centers in the US as reported by Faintich (1979). The merger of remote sensing data with geographic information systems, in general, is similarly an emerging and promising technique of combining data from maps, overlays, air photos/orthophotos and tabular data with LANDSAT and/or other remote sensing imagery. The resulting products are assemblages of data in a multivariate, multitemporal, three dimensional model of the spatial-temporal world. The process has been referred to as "landscape modeling" (Tom and Miller, 1980) and is a good indication of future directions in cartography and remote sensing.

CONCLUSIONS

The billions of picture elements (pixels) that have been remotely sensed over Latin America in the last decade will probably be duplicated exponentially in the 1980s. Their value as finite, spatial and temporal records of the environment will be incomparable for the investigation and development of the natural resources of the region. Their information carrying capacity will supersede to some degree the

COURSE NO.	COURSE TITLE	CONTENT	HOURS
P-311	INTRO. TO REMOTE SENS.	*BASICS *ACQUISITION SYSTEMS *VISUAL ANALYSIS *APPLICATIONS	160
P-312	APPLIED REMOTE SENS.	*APPLICATIONS *VISUAL ANALYSIS *PRACTICAL EXERCISES	80
P-313	DIGITAL REMOTE SENS.	*CCT FORMATS *PATTERN RECOGNITION *CLASSIFICATION *IMAGE PROCESSING	80

TABLE 2. IAGS CARTOGRAPHIC SCHOOL COURSES IN REMOTE SENSING, 1982

conventional line and topographic map. Their natural surface images will be viewed and used by a new generation of "map" readers trained in the interpretation and comprehension of non-symbolic cartography. The image products will be generated in a variety of forms, but primarily from a digital data base. The imagery will reasonably become the primary data acquisition source of the future for the standard general map as concluded by Robinson et al (1977). It could evolve as the primary content of that huge data base which would conceptually constitute the short-lived, temporal map of the future, capable of being displayed on a CRT screen and altered, manipulated and hard copied for some specific, immediate use. This image has been termed a "non-map" by Yoeli (1975), "temporary map" by Riffe (1970) and "virtual map" by Moellering (1975).

The optimistic scenario envisioned for remote sensing for the 1980s applies to the world user community in general and most auspiciously to Latin America. The indicators are all there for a viable market, vastly expanded beyond past activities and data usage, and supported by the national and international institutions active in the technology transfer.

REFERENCES

Adrien, Pierre-Marie, and Luis A. Bartolucci, "Remote Sensing Technology and New Development Trends in Latin America", Proceedings of the Twelfth International Symposium on Remote Sensing of Environment, Environmental Research Institute of Michigan, April 1978, pp. 187-201.

Chevrel, M., M. Courtois and G. Weill, "The SPOT Satellite Remote Sensing Mission", Photogrammetric Engineering and Remote Sensing (P.E. & R.S.), Vol. 47, No. 8, August 1981, pp. 1163-1171.

Colvocoresses, A., "Proposed Parameters for MAPSAT", P.E. & R.S., Vol. 45, No. 4, April 1979, pp. 501-506.

Conitz, M., "A Development Assistance Program in Remote Sensing, P.E. & R.S., Vol. 44, No. 2, February 1978, pp. 177-182.

Crane, D., "Invisible Colleges: Diffusion of Knowledge in Scientific Communities, Chicago, 1972.

Doyle, F. J., "The Next Decade of Satellite Remote Sensing", P.E. & R.S., Vol. 44, No. 2, February 1978, pp. 155-164.

Faintich, M. B., "Digital Image Technology: MC&G Impact", Harvard Computer Graphics Week '79, 15-20 July 1979, reprinted in the Proceedings of the American Society of Photogrammetry, Annual Convention, St. Louis, MO, 9-14 March 1980, pp. 32-43.

IAGS, "Survey of Satellite Remote Sensing Data Users in Latin America", Unpublished Report, IAGS-PP, 1978.

IAGS, "Course Catalog and Descriptions, January-December 1982", IAGS Cartographic School, Fort Clayton, Panama, September 1981.

Mead, R. A., "Occupational Preparation in Remote Sensing", Vol. 45, No. 11, November 1979, pp. 1513-1515.

Moellering, H., "Interactive Cartography", Proc. Inter. Symp. on Computer-Assisted Cartography, 1975,

NASA, LANDSAT Data Users Notes, USGS, EROS Data Center, Issue No. 17, March 1981.

Paul, C. K., Agency for International Development, Washington, D. C., Personal Communication, August 1981.

Riffe, P., "Conventional Map, Temporary Map or Non-map?" Inter. Yearbook of Cartography, Vol. 10, 1970, pp. 95-103.

Robinson, A., J. Morrison and P. Muehrcke, "Cartography 1950-2000", Transactions, New Series of the Institute of British Geographers, Vol. 2, No. 2, 1977.

Spann, G. W., "Satellite Remote Sensing Markets in the 1980s", P.E.&R.S., Vol. 46, No. 1, January 1980, pp. 65-69.

Tom, C. H., and L. D. Miller, "Forest Site Index Mapping and Modeling", P.E.&R.S., Vol. 46, No. 12, December 1980, pp. 1585-1596.

Thompson, L. L., "Remote Sensing Using Solid-State Array Technology", P.E.&R.S., Vol. 45, No. 1, Jan 1979, pp. 47-55.

Welch, R. "Measurements from Linear Array Camera Images", P.E.&R.S. Vol. 46, No. 3, March 1980, pp. 315-318.

Welch, R., and W. Marko, "Cartographic Porential of a Spacecraft Line-Array Camera System: Stereosat", P.E.&R.S. Vol. 47, No. 8, Aug 1981, pp. 1173-1185.

Wharton, S. W., Irons, J. R. and Huegel, F., "LAPR: An Experimental Pushbroom Scanner", P.E.&R.S., Vol. 47, No. 5, May 1981, pp. 631-639.

Yoeli, P., "Methodology of Computer-Assisted Cartography", Display and Analysis of Spatial Data, John Wiley & Sons, 1975, pp. 130-136.